

**EMBOLOCEPHALUS YAMAGUCHII (BRINKHURST, 1971) (CLITELLATA: TUBIFICIDAE)  
FROM SOUTH AUSTRALIAN STREAMS**

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Papillate tubificids from streams in the Mount Lofty Ranges are identified as *Embolocephalus yamaguchii* (Brinkhurst, 1971) and represent the first records of this largely Holarctic genus from Australia. Collection details are provided for records of a second papillate species, identified as belonging to the genus *Spirosperma*.

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Most tubificids with papillate body walls are contained within a complex of genera (including *Embolocephalus* Randolph and *Spirosperma* Eisen) established, or re-established, following revision of the genus *Pelosclex* Leidy (Brinkhurst 1991; Brinkhurst & Wetzel 1984; Holmquist 1978, 1979). These genera have a largely Holarctic distribution, with few records from southern continents. The latter consist of a record of the otherwise European *Embolocephalus velutinus* (Grube, 1879) from Venezuela (Dumnicka, 1983), an identification questioned by Brinkhurst and Marchese (1989), and papillate tubificids of uncertain identity from Peru (Brinkhurst & Marchese 1989). The North American species *Quistadrilus multisetosus* has been recorded as far south as Mexico. In Australia, Timms (1978) recorded *Pelosclex* (*sic*) from a lake in Tasmania and Pinder & Brinkhurst (1994, 2000) noted papillate tubificids from Victoria and New South Wales. The latter were all immature so descriptions were not possible, but they were tentatively assigned to *Spirosperma*, based on the presence of papillae and the form of the chaetae. Collection details for this species, including the first records from South Australia, are presented below for the first time. Other specimens, collected from streams in the Mount Lofty Ranges in South Australia, are herein described and identified as *Embolocephalus yamaguchii* (Brinkhurst, 1971), a species otherwise known only from Lake Biwa in Japan.

METHODS

Serially sectioned specimens were cut at 6 µm and stained in haematoxylin and eosin. Measurements were taken using an eyepiece graticule on a Zeiss Jenamed 2 compound microscope calibrated with an Olympus stage micrometer. Abbreviations used in the line-drawings are a: atrium, cp: cuticular pad, e: large epidermal papillae, ed: ejaculatory duct, ff: female funnel, mf: male funnel, p: prostate, pe: penis, sa: spermathecal ampulla, sc: spermathecal chaeta, scg: spermathecal chaetal gland, v: vas deferens. Specimens are either in the senior author's collection (AP) or the Australian Water Quality Centre collection (AWQC); returned to WSL Consultants (WSL) or Australian Water Technologies (AWT); or deposited with the South Australian Museum (SAM) or the Museum of Victoria (NMV).

SYSTEMATICS

*Embolocephalus* Randolph, 1892

*Type species*

*Embolocephalus velutinus* (Grube, 1879)

*Diagnosis*

From Holmquist (1978) and Brinkhurst (1981). Prostomium and sometimes first segments retractable within the rest of body. Body wall with epidermal papillae, generally concealed by a

secreted layer with embedded foreign particles. Hair chaetae present dorsally, usually broad and sabre-like, with pectinate crotchet chaetae. Bifid and/or simple pointed chaetae present ventrally, usually both in anterior bundles. Spermathecal chaetae modified on X, lying in a well-developed chaetal sac. Male ducts each with a long winding vas deferens, usually narrower entally and broader (up to twice the width) ectally, entering the atria apically. Atria long and tubular to crescentic, broadest near the prostate union, tapering to a short ejaculatory duct. One large prostate gland joining each atrium towards the middle of the latter. Penes well developed without thickened cuticular sheaths. Spermathecae with ovoid to oblong ampullae, well set off from the ducts, with pores usually more or less in front of and lateral to the spermathecal chaetal sacs.

#### *Distribution*

Europe, North America, Japan, Kamchatka, ?Venezuela and now Australia.

*Embolocephalus yamaguchii* (Brinkhurst, 1971)

*Peloscolex yamaguchii* Brinkhurst, 1971: 505

*Peloscolex* sp. Yamaguchi, 1953: 295

*Embolocephalus yamaguchii* (Brinkhurst, 1971) Ohtaka, 1994: 52; 1995: 174

#### *Material examined*

South Australian specimens. SAM E3095–3101: 3 mature specimens serially sectioned, 3 mature dissected and 1 immature whole-mounted, Aldgate Creek at Strathalbyn Road, Mylor, tributary of the Onkaparinga River (AWQC site 3217), 35°02'S 138°45'E, samples E33, 3 June 1997 and F32, 27 Oct 1997. AP: 1 mature serially sectioned, collected as above. SAM E3102–3103: 1 mature in alcohol, Onkaparinga River at Houlgraves Weir (AWQC site 3205), 35°05'S 138°43'E, sample E37, 3 June 1997, and 1 mature whole-mounted from same site, sample F37, 28 Oct 1997. SAM E3104: 1 mature in alcohol, Aldgate Creek at Aldgate Valley Road (AWQC site 13022), 35°02'S 138°45'E, sample H41, 2 Dec 1998. AWQC: 5 immature in alcohol, Onkaparinga River at Hack Bridge (AWQC site 3212), 35°03'S 138°45'E, sample H43, 1 Dec 1998. AWQC: 1 immature in alcohol, Lenswood Creek at gauging station (AWQC site 3208),

34°56'S 138°50'E, sample OCB148, 17 Jul 2000: AWQC: 2 mature in alcohol, Onkaparinga River at Silver Lake Road (AWQC site 13023), 35°04'S 138°45'E, sample OCB181, 17 Oct 2000. Collections by V. Tsymbal, P. McEvoy, A. Lang and S. Wade (Australian Water Quality Centre, South Australia).

Japanese specimens. From collection of A. Ohtaka (Hirosaki University, Japan): 1 mature specimen serially sectioned, 1 mature whole-mounted and 2 mature in alcohol (now dissected), Lake Biwa, Japan.

#### *Habitat*

This species has been collected only from a sixth order reach of the Onkaparinga River upstream of Mount Bold Reservoir and from two fourth order tributaries, between 245 and 295 metres above sea level. Specimens were collected from both riffle and edge habitats, with substrates ranging from those composed mainly of bedrock, boulder or cobble to those dominated by finer sediments and/or detritus. Willow root mats are a common feature on the stream bed of most sites. Riparian zones had an overstorey of either indigenous *Eucalyptus* species and *Acacia melanoxylon* and/or introduced willows (*Salix* spp.). Land uses include grazing, horticulture and urban settlement. Apparently similar habitats in adjacent catchments were sampled with the same sampling intensity without finding *E. yamaguchii*.

#### *Description of Australian specimens*

Length of preserved specimens 15.6–25.5 mm, width at clitellum 0.7–1.1 mm. Each pre-clitellar segment with a band of tall, broad epidermal cells forming a raised transverse ridge in the middle of the segment, pronounced dorsally and laterally but virtually absent ventrally. Body surface with foreign material adhered to elongate ovoid papillae covering the entire body except for the clitellum (Fig. 1). Papillae mostly 15–22 µm long on pre-clitellar segments (measured on the longest axis, including foreign particles) and 20–34 µm long on post-clitellar segments, and mostly 17–25 µm high (with most of the height constituted by the foreign material). Ridges of anterior segments with fewer or no papillae. Each segment also with 2 rings of papillae that are taller and broader than normal (up to 40 µm wide and 40 µm high including foreign material), which give the appearance of darker (or sometimes lighter) bands around each segment, 1 ring about at the level of the chaetae and 1 anteriorly on each segment, most pronounced on posterior segments.

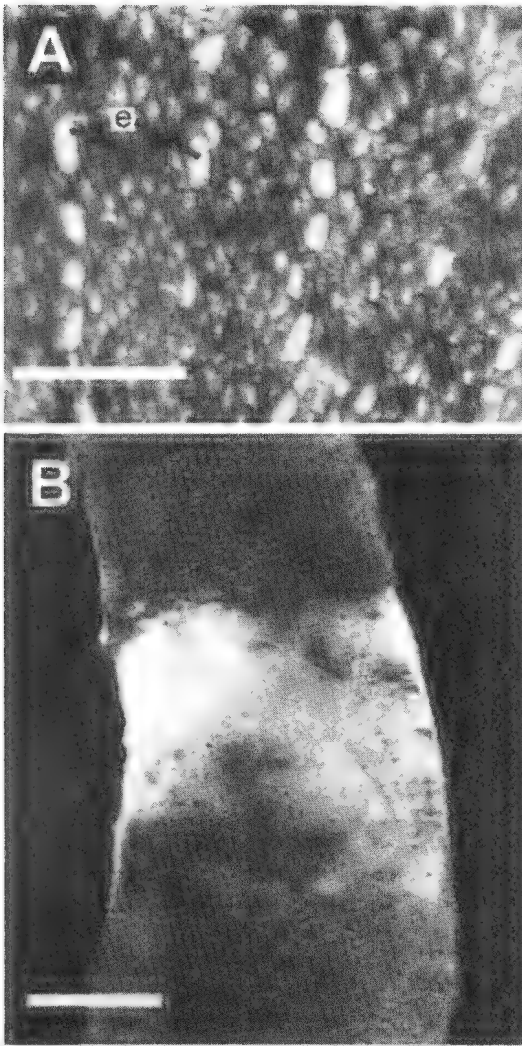


FIGURE 1. *E. yamaguchii* A, Enlarged view of body wall of segments towards the posterior end of SAM E3098 (prior to slide mounting) showing normally sized and enlarged (e) papillae; B, Portion of SAM E3104 showing lateral view of anterior segments (top), clitellum (centre) and post-clitellar segments (bottom). Scale bar for A 100  $\mu$ m, B 500  $\mu$ m.

Other (possibly sensory) papillae present with the foreign material adhered only to the sides, with the top of the papillae exposed, arranged in ill-defined rings around each segment (about 10 of these papillae per ring), usually 1 ring at the level of the chaetae and 1 or more rings between the chaetae and intersegmental furrow. These partially naked papillae are about the same size as the

shorter type of fully encased papillae and are sometimes visible as darker or paler spots. A pad of tall, thin epidermal cells, with cuticle 10 times thicker (up to 17  $\mu$ m) than elsewhere, present medially on the spermathecal segment, adjacent to the anterior spermathecal chaeta. Clitellum covering posterior half of X and all of XI, paler than other segments due to a smooth even coating of soft white granular material (Fig. 1).

Prostomium partially retracted into first segment in fixed animals. Pharynx with dorsal muscular pad in II to III, with pharyngeal gland cells on pharynx and on septa 3/4 to 4/5. Oesophagus from IV to VI, widening into broader thicker-walled intestine in VII.

Ventral chaetae 130–211  $\mu$ m long and 7–14  $\mu$ m wide at nodulus, generally smallest in pre-clitellar bundles. Ventral bundles on II to VIII usually with 1 bifid and 1 simple pointed chaeta, rarely 1 extra bifid chaeta and/or 1 or 2 extra simple pointed chaetae. Bifid chaetae with teeth equal in width but upper tooth up to 1.5 times longer than lower (Fig. 2B). Posterior ventral bundles with 1 (rarely 2) bifid chaetae, with upper teeth becoming shorter than lower and lower tooth greatly expanding in width and becoming notably recurved (Fig. 2C). Dorsal chaetal bundles normally with 2 to 4 slightly curved hair chaetae, 220–420  $\mu$ m long and 4–7  $\mu$ m wide, with finely plumose shafts and blunt, slightly swollen, tips, with an equivalent number of short (32–75  $\mu$ m long and 1–2  $\mu$ m wide) finely pectinate crotchets with thin parallel outer teeth (Figs 2D,E). Posterior dorsal bundles with fewer of both types of chaetae. Chaetae of spermathecal segment modified (Figs 2A, 3A,B), ventral chaetae absent in XI.

Genitalia paired (Figs 2, 3B). Testes anteroventral in X, ovaries anteroventral in XI. Male funnels large, ciliated vasa deferentia broad near funnels (35  $\mu$ m), narrowing shortly thereafter (17–20  $\mu$ m) and widening slightly ectally (25–33  $\mu$ m), highly coiled, joining ental end of atria. Atria each with a narrow lumen and layer of tall glandular lining cells, crescentic, broadest where a single prostate gland joins (slightly entad of medial), tapering at either end, the ectal end forming a short ejaculatory duct which enters the penis apically. Atrial muscle layer thin, wider where prostate joins. Atrium, including ejaculatory duct, measuring 800 x 110  $\mu$ m to 1000 x 185  $\mu$ m. Prostate glands voluminous, sometimes ballooning into following segment. Penes broad entally, narrowing at about one-third of the distance from the tip to form a narrower ectal end,

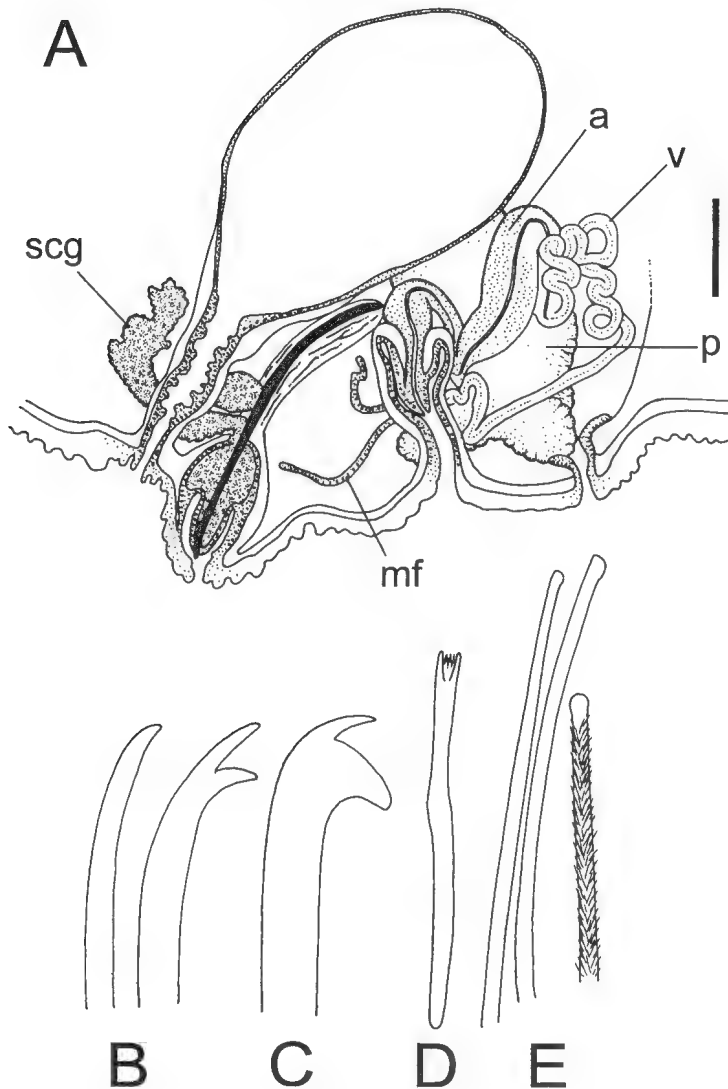


FIGURE 2. *E. yamaguchii*. A, Reconstruction of genitalia (with organs drawn in the same plane for simplicity) from serial sections of SAM E3095; B, tips of anterior ventral chaetae; C, tip of posterior ventral chaeta; D, dorsal pectinate chaeta; E, tips of dorsal hair chaetae, with plumosity shown for one hair. Scale bar for A 200  $\mu\text{m}$ .

penes within thin-walled muscular penis sacs attached to the dorsolateral body wall by numerous muscle fibres. Penes and penis sacs with cuticle no thicker than on body wall (ie without penis sheaths). Male pores in line with ventral chaetae on anterior half of XI, within a common transverse depression of the ventral body wall. Spermathecal ampullae variable in size (770–1350  $\mu\text{m}$  long), each containing 1 or 2 long thin spermatozeugmata (length of only one whole

spermatozeugmata measured, 660 x 45  $\mu\text{m}$ , but others 80  $\mu\text{m}$  wide in cross-section, indicating greater length). Spermathecae with stout ducts (300–370  $\mu\text{m}$ ) that are constricted ectally, leading to pores anterior on X slightly medial to line of ventral chaetae. Spermathecal chaetae long (510–670  $\mu\text{m}$ ) and thin (10  $\mu\text{m}$ ) with grooved tips, ectal half lying in well-developed chaetal sacs. The sacs tall (220–300  $\mu\text{m}$ ) and muscular, with inner lining tissue that can be everted with the tip of the chaeta

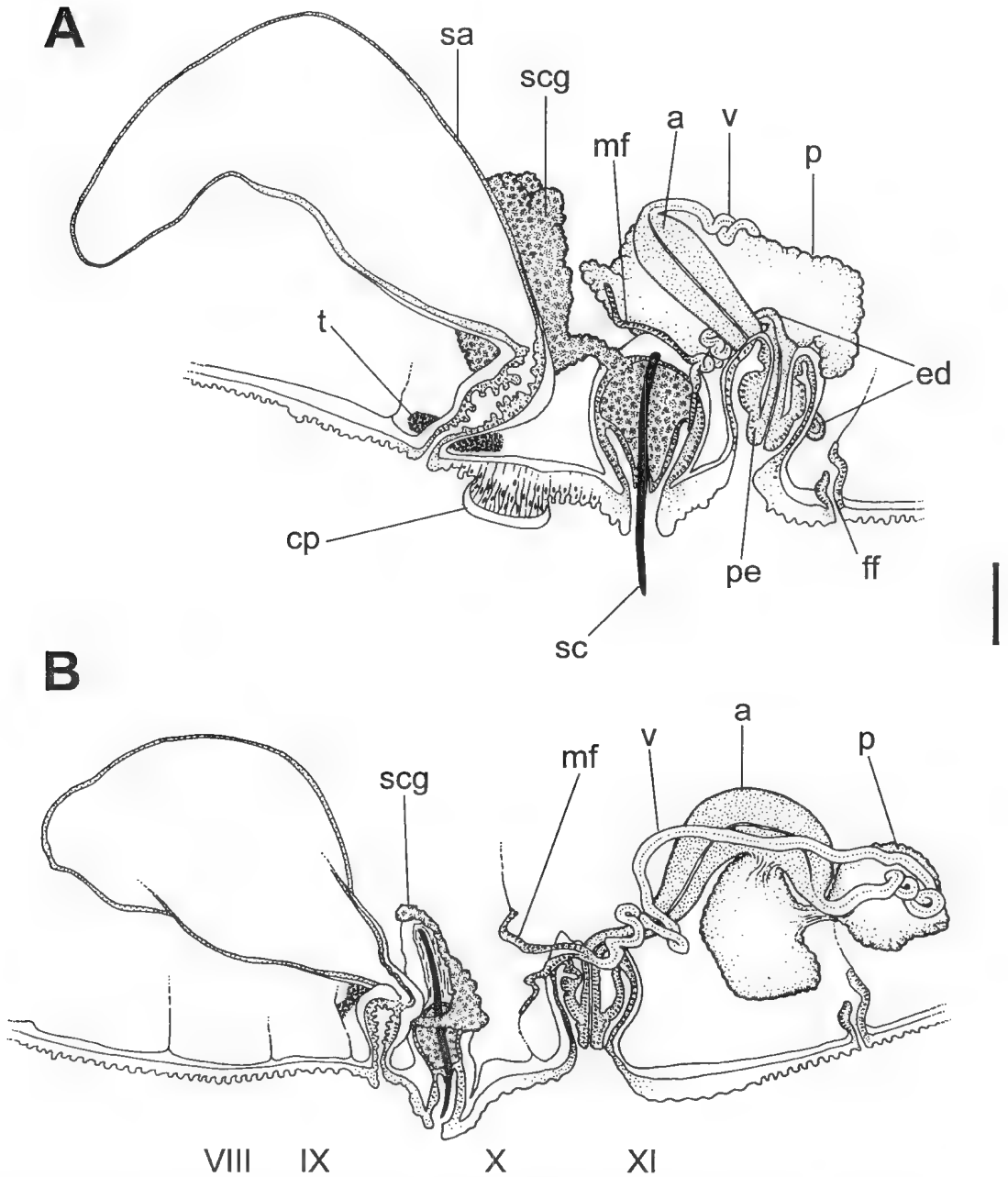


FIGURE 3. *E. yamaguchii*. Reconstruction of genitalia (with organs drawn in the same plane for simplicity) from serial sections of A, SAM E3096 and B, SAM E3097. Scale bar for A 200  $\mu$ m.

to form a large papilla and with muscular layer extending to cover the ental end of the chaeta. Sacs with a gland attached dorsally, varying in extent of development (between and within individuals). Spermathecal chaetal sacs located asymmetrically,

both opening slightly ventral to the line of somatic ventral chaetae, 1 immediately posterior to spermathecal pore on one side and the other close to 11/12 in front of the sperm funnel on other side. Female funnels posterolateral on XI.

*Remarks*

The presence of simple-pointed chaetae on segments II to VIII, separate openings for the spermathecal ducts and spermathecal chaetae, dorsolateral ridges on anterior segments and asymmetrical location of the spermathecal chaetae clearly ally these Australian specimens with the Japanese species *E. yamaguchii* rather than with any of its congeners. We initially considered that the Australian specimens were either conspecific with *E. yamaguchii* or represented a very similar sister-species. The latter was seen as more likely since *E. yamaguchii* is known only from Lake Biwa in Japan and other *Embolocephalus* seem to have fairly restricted Holarctic distributions. However, a thorough comparison of *E. yamaguchii* (from the description in Ohtaka 1994 and material seen by us) and the Australian specimens led to the conclusion that there was no morphological justification for a new species description. The only differences between the Australian and Lake Biwa specimens are the size of the worms and the size of some genital organs. None of the Australian specimens reach the maximum length of 35 mm measured for the *E. yamaguchii* neotypes (Ohtaka 1994), but most Lake Biwa specimens are less than 30 mm (Ohtaka pers. comm.). The vasa deferentia of the Australian specimens are narrower than those (20–24 µm wide entally, 40 µm ectally) recorded for *E. yamaguchii* by Ohtaka (1994) and the ectal portion is not so enlarged relative to the ental portion. However, the vasa deferentia of Lake Biwa specimens measured by us (as narrow as 13 µm entally to a maximum of 25 µm ectally) more closely match measurements from the South Australian material. Other components of the genitalia (atria, spermathecal ampullae and spermathecal chaetae) are slightly larger in the Australian specimens than recorded by Ohtaka (1994). The raised epidermal pad was not noted for *E. yamaguchii* by Ohtaka (1994) but was present on Lake Biwa material seen by us and is visible in Fig. 4B of Ohtaka (1994). This feature is not known for other *Embolocephalus* species.

These specimens represent the first records of this species and genus in Australia and one of the few records of the genus from southern continents. The known distribution of this species (Lake Biwa in Japan and the Mount Lofty Ranges in South Australia) is exceptional within the Australian tubificid fauna. Other tubificids found in Australia are either endemic or cosmopolitan (occurring in most, if not all, other continents).

*?Spirosperma* sp.*Material examined*

All specimens immature. WSL consultants voucher AN30: 2 in alcohol, Old Namoi River at Bullerawa Station, (Duncan's Junction) New South Wales, 30°18'05"S 149°04'00"E, 27 Jun 2000. AWT: 1 specimen, Georges River at Cambridge Avenue, New South Wales, 33°58'S 150°54'E, 1 Apr 1996; 1 specimen, Peach Tree Creek, at Weir Reserve, New South Wales, 33°45'S 150°41'E, 17 Jul 1996; 1 specimen, Second Ponds Creek downstream of Rouse Hill Sewage Treatment Ponds, 33°40'S 150°55'E, 1 Apr 1996. AP: 1 whole-mounted on slide, Plenty River at Lower Plenty, Victoria, 37°44'S 145°06'E, 10 Apr 1994, coll. S. Schreiber (formerly Monash University); Glenelg River at Rocklands, Victoria, 37°14'S 141°57'E, 3 Jun 1994, coll. S. Schreiber. NMV F81865: 1 in alcohol, LaTrobe River at Moe-Willow Grove Road Bridge, Victoria, 38°11'18"S 146°15'12"E. NMV F81864: 1 in alcohol, Curdies River, Victoria, 38°20'S 143°08'E, 7 Feb 1992, coll. G. Quinn (formerly Monash University). AWQC voucher 5665: 1 in alcohol, Pilby Creek outlet (AWQC site 13095), South Australia, 33°59'S 140°53'E, 24 Nov 1998, coll. D. Schulze and T. Venus.

*Brief description*

Prostomium retractable within mouth. Body wall densely papillate, with foreign material

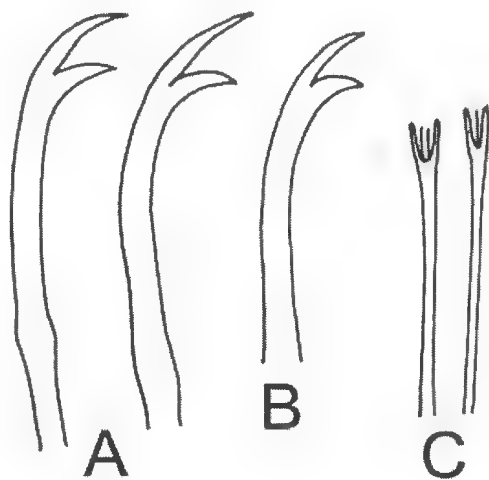


FIGURE 4. *Spirosperma* sp. A, ventral chaetae of anterior to mid-body segments; B, ventral chaeta of posterior segment; C, tips of dorsal crotchet chaetae.

attached to most papillae. Some papillae with foreign matter on lateral walls only. Without rings of distinctly larger papillae. Ridges of enlarged epidermal cells absent on anterior segments. Ventral chaetae (Fig. 4) all bifid, 3 to 6 per bundle, with upper teeth 2 to 3 times as long as lower teeth in anterior and mid-body segments, 1.5 times as long as lower teeth in posterior segments (Fig. 4). Ventral chaetae of first few segments usually slightly longer and thicker than the rest. Dorsal bundles with 1 to 3 smooth hair chaetae and 1 to 3 very small crotchet chaetae with finely bifid ends and 1 or 2 intermediate teeth (Fig. 4).

#### Remarks

This species lacks simple-pointed chaetae anteriorly and so has been tentatively identified as a *Spirosperma* rather than an *Embolocephalus*, but mature specimens are required to confirm the generic affiliation. It appears to be widespread in rivers of southeastern Australia.

#### ACKNOWLEDGMENTS

Specimens of *E. yamaguchii* were collected as part of the Monitoring of River Health Initiative funded by the Land and Water Resources Research and Development Council and Environment Australia. Funding from the Wildlife Conservation Fund of the Department for Environment and Heritage (South Australia) enabled identification to species of oligochaetes from the above project. Laboratory and microscope facilities were made available by Stuart Halse (Department of Conservation and Land Management). Specimens of *Spirosperma* were made available by Australian Water Technologies, Alena Glaister at Monash University and Kylie Swingler at WSL Consultants (specimens from a Department of Land and Water Conservation NSW project). Akifumi Ohtaka (University of Hirosaki, Japan) kindly provided material of *E. yamaguchii* from Lake Biwa and engaged in useful discussions with the authors. Gordon Thomson (Murdoch University, Perth) performed the serial sectioning and Jane McRae (Department of Conservation and Land Management) assisted with photography.

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